



# Air quality design considerations in industrial and commercial buildings

## An introduction to the Industrial HVAC Design Guidelines

for Commercial HVAC Design Engineers

**T**he majority of heating, ventilation and air conditioning (HVAC) design engineers are familiar with the importance of indoor air quality/indoor environmental quality (IAQ/IEQ) in commercial buildings. These two criteria in commercial buildings primarily focus the design effort on the health, safety, and comfort of the building occupants.

Designing commercial building HVAC systems well requires a thorough understanding of ASHRAE Standard 62.1: Ventilation for Acceptable Indoor Air Quality relative to ventilation requirements, ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy for indoor comfort conditions including air movement and how humans react to temperature and humidity and the International Green Construction Code. Much of this experiential knowledge also relates to many of the key IAQ/IEQ considerations in industrial manufacturing and packaging facilities.

The design of industrial facilities focuses primarily on the process being carried out more so than on the comfort of occupants running or monitoring the processes, though the latter is still important. Industrial facilities, such as chemical processing, food production, packaging and warehousing, consumer product manufacturing, or a combination of these operations, tend to give primary attention to temperature, humidity and the presence or concentration of certain gases that affect the processes occurring in the building.

However, even in such settings, occupant safety is the one design consideration that takes precedence over the production process. Especially within the IAQ/IEQ realm, hazards to occupant respiration are the top priority.

In specialized industrial facilities, such as pharmaceutical production, chip-set fabrication, biological testing or biologic production facilities, the design may also need to address the cleanliness of the ambient production environment with stringent requirements on the acceptable quantity and size of particulates in the air. When the manufactured product can be microscopic in scale, such as with computer chip set integrated circuits, the presence of otherwise negligible dust and lint particles may invalidate the product being manufactured.

In certain classes of drugs that are injected directly into the body, or in the production and laboratory testing of gene and cell therapy lines, the concerns extend beyond the particulates to encompass pathogens that might be carried into the process on those airborne particles.

Overall, the concerns for indoor air and environmental quality within industrial facilities can have much greater stakes than in commercial buildings. Where the impact in a commercial facility may extend to hundreds or thousands, of occupants and their comfort, the impact in an industrial facility can affect tens of millions of consumers. Additionally, the economic and reputational cost to manufacturers can be astronomical.

### Learning Objectives

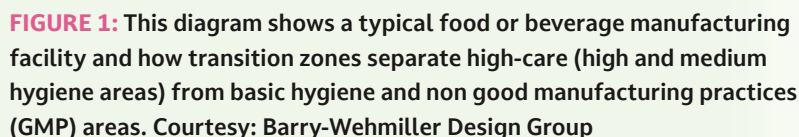
- **Understand how** IAQ/EAQ design features in commercial buildings can be used in industrial facilities.
- **Identify** the various governmental and third-party agencies that provide guidance for industrial facility design.

The ultimate goal of IAQ/EAQ design in commercial facilities such as offices, malls, educational facilities and transportation centers is to engineer a healthy, comfortable environment for human habitation within the building. ASHRAE Standard 62.1, ASHRAE Standard 55, the International Green Construction Code and other standards, guidelines and codes serve as a yardstick, prescribing the minimum acceptable IEQ/IAQ criteria or enhancing them.

As responsible design professionals implementing the aforementioned features in the design of buildings, it is imperative to focus on the following key elements, provided by Whole Building Design, as applicable:

- Adequate indoor air quality through filtration and quantity of ventilation air supply and exhaust for acceptable indoor air quantity
- Temperature and airflow controllability for thermal comfort
- HVAC systems that manage moisture sources and provide indoor humidity control
- Achieve indoor environmental quality through the design of efficient systems, construction adherence to design documents, commissioning, operation and maintenance practices
- Designing a properly illuminated environment per Illuminating Engineering Society (IES) recommendations
- Designing energy efficient systems relative to the use of individual spaces or buildings
- Provide for high-quality, potable water

In comparison to occupant-centric commercial IAQ/IEQ design, the primary focus of industrial design is on the manufacturing process, as it can potentially affect the quality and consistency of mass-produced products. Deviating from product criteria due to unacceptable variations in IAQ/IEQ can cause entire batches of product to be out of acceptable specifications, thus invalidating massive



Occupational Safety and Health Administration (OSHA) has established average exposure limits for acceptable levels of contaminants, temperature or humidity for humans over an eight-hour window. However, industrial processes generally do not have such tolerances since the products are precisely measured and processes are developed for producing consistent, uniform and safe products in mass quantities. Fluctuating environmental conditions can lead to product specification or quality variability, which is unacceptable. When sterility is an additional requirement, any duration of exposure to pathogens beyond limits can also void the entire process, cause serious harm and be fatal to end users.

The key design elements for good industrial IEQ/IAQ design include the following:



- Adequate quality and quantity of ventilation air supply and exhaust for acceptable indoor air quantity
- Temperature and airflow controllability for stable process and production consistency
- HVAC systems that maintain hygienic zoning, proper management of moisture sources and adequate indoor humidity control
- Achieve indoor environmental quality through the implementation of good manufacturing practices (GMPs), construction adherence to design documents, commissioning, operations and maintenance practices
- Designing a properly illuminated environment per IES and production specific requirements
- Designing energy efficient systems relative to the use of individual spaces or the building as a whole
- Provide for high-quality, potable water
- Facilitating the production process to operate in as hygienic and sterile environment as required to ensure the highest quality end product

- **Process air movement:** In addition to worker safety, there are also considerations for the production process. For most industrial applications, the higher the hygiene requirement, the higher the air exchange rate to minimize the concentration of contaminants to the process. Where typical air exchange rates for commercial buildings are six air changes per hour (ACH) for human ventilation dilution, process applications require air exchange



rates of 10 ACH up to 30 ACH. Clean room applications require air exchange rates near 50 ACH. The volume of air movement becomes more confined as the environment is subject to more stringent criteria. Otherwise, the absolute air movement quantity in cubic feet per minute become untenable for large volume spaces. Figure 2 depicts air pressurization strategy for air movement in a properly hygienic zoned facility.

## Industry regulatory agencies

Responsible designers are expected to be aware of the specific industry requirements pertaining to the process being designed. Following are some of the agencies relevant to industrial processes and their codes, standards and/or guidelines:

**OSHA:** Under the U.S. Department of Labor, OSHA ensures safe and healthy working conditions for workers by setting and enforcing standards and by providing training, outreach, education, and assistance. Specific to IAQ/IEQ, it has published ventilation standards including the four standards in OSHA Standard 29 CFR 1910.94 dealing with local industrial exhaust systems. Additionally, it publishes Standard 1910 Subpart Z: Toxic and Hazardous Substances, Table Z-1. This publication includes occupational exposure limits (OELs) for approximately 500 substances with either a maximum instantaneous value, a 15 minute time weighted average or an exposure limit — based on an eight-hour time weighted average exposure. OELs for hundreds of additional substances have been adopted by OSHA, The National Institute for Occupational Safety and Health (NIOSH) and ACGIH.

**NIOSH:** This U.S. Government research agency focuses on the study of worker safety and health, and empowers employers and workers to create safe and healthy workplaces. NIOSH is part of the U.S. Centers for Disease Control and Prevention, in the U.S. Department of Health and Human Services. It has published several useful criteria documents, current intelligence bulletins, reports, fact sheets and impact sheets. These provide technical guidance on controlling worker exposure to airborne contaminants, nanoparticles, tobacco smoke, heat and to various chemicals and biological agents.

**ACGIH:** The ACGIH Industrial Ventilation Committee publishes “Industrial Ventilation, a

Manual of Recommended Practice for Design.” This manual is recognized worldwide as one of the key design guides for all aspects of industrial ventilation design and applications. The topics covered include equipment fundamentals, associated system design, local exhaust system design, general industrial ventilation principles and design, supply air system design and special design considerations. The manual compiles references and aggregates data, recommended practices, and code references from many different resources into one compendium.

Additionally, ACGIH publishes an annually updated version of a booklet of threshold limit value occupational exposure guidelines for more than 700 chemical substances and physical agents. There are also more than 50 biological exposure indices that cover more than 80 chemical substances. ACGIH also publishes the Guide to Occupational Exposure Values, which supplements threshold limit value and biological exposure indices exposure guidelines with an accessible reference of the most recently published values.

## Conclusion

Prioritizing IAQ/IEQ considerations in both commercial and industrial setting is vital. The former places more emphasis on the occupants’ health and comfort whereas the latter places it on maintaining precise conditions to ensure product quality and occupant safety. Compliance with standards and guidelines such as ASHRAE, ACGIH and OSHA, are essential to create safe and efficient industrial environments. Incorporating the appropriate design approach with adherence to industry-specific requirements is the key to a safe, sustainable and successful industrial environment while safeguarding the health and well-being of workers and consumers. **cse**

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### Ventilation insights

- ▶ **In commercial buildings,** the focus of HVAC design is on the health, safety and comfort of the occupants, whereas in industrial buildings the focus shifts to the production process while still prioritizing occupant safety.
- ▶ **Many industrial facilities** will often have stricter guidelines dependent on the kind of product being made.